

SENSORS & CONTROLS

Project Fact Sheet



IN-SITU, REAL-TIME MEASUREMENT OF MELT CONSTITUENTS

BENEFITS

- A cumulative reduction of 55 to 83 trillion Btu per year, with a breakout of 12 trillion Btu reduction for the aluminum industry, 17 to 45 trillion Btu for the glass industry, and 26 trillion Btu for the steel industry
- In-situ, real-time, simultaneous determination of melt constituents and temperature with a system costing less than \$100,000
- Data for use in a feedback control loop to control the furnace operation in real time
- Minimization of glass product rejections resulting from variations in glass melt composition and non-repeatability in the mechanics of forming
- Elimination of the aluminum and steel furnace idle time now required for off-line measurement of melt constituents

APPLICATIONS

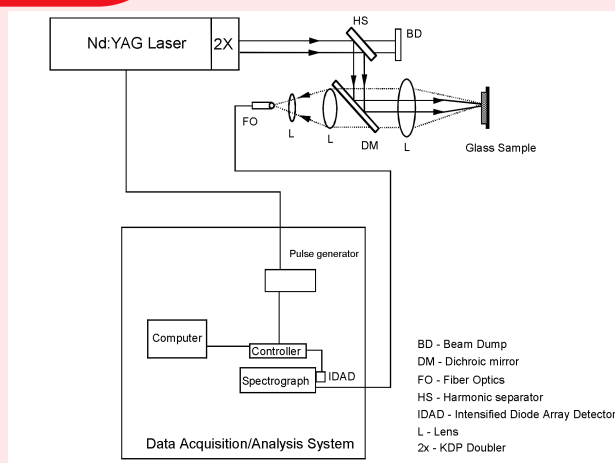
The primary target applications are in the aluminum, glass, and steel industries. In the glass industry, application is especially suited for monitoring of trace alkali metal content in electronic glasses, compositions to meet the defined specifications for waste-vitrified glasses and sealing glasses, and the concentration of refractory dissolved in the glass to diagnose the state of the furnace. Applications in the aluminum and steel industries relate to in-line alloying by measuring during a pour, continuous and semi-continuous furnace operations by minimizing the current practice of off-line sampling and measurement, in-line monitoring of removal of impurities from the melt such as the removal of magnesium from molten aluminum, and validation of computer simulation and modeling of furnaces with real-time data.

LASER-INDUCED BREAKDOWN SPECTROSCOPY WILL PROVIDE REAL-TIME ELEMENTAL CONSTITUENTS FOR PRODUCT QUALITY CONTROL

This technology employs a laser-induced breakdown spectroscopic (LIBS) technique to measure, in situ and in real time, the constituents of the melt in a process furnace. Currently, elemental analysis is conducted by periodically grabbing a molten sample and taking it to a lab for analysis. This is expensive and time consuming, and it does not allow real-time control. By allowing in-situ, real-time measurement of melt constituents, this technology will improve product quality by reducing defects, increase furnace cycle times leading to continuous and semi-continuous operations, increase furnace life by diagnosing the state of the furnace, and provide necessary data to develop and validate computer modeling and simulation leading to increased automation of furnace operations.

The commercial LIBS technique for in-situ analysis of molten steel is too costly, ranging from \$750,000 to \$2 million. This project will produce a system under \$100,000 that overcomes the cost barrier for technology acceptance based on discussions with industry representatives.

LIBS PROBE



A probe that uses LIBS to determine the elemental constituents in an aluminum, glass, or steel melt will be developed. This LIBS probe will measure continuously and in-situ at any point in the melt, thus providing real-time data, both spatially and temporally. This technology will improve product quality, increase furnace production, reduce energy use, allow continuous furnace operation, and validate computer models.



Project Description

Goal: Develop and test a LIBS-based probe in a laboratory crucible furnace to demonstrate in-situ, real-time measurement of aluminum melt constituents with an accuracy and minimum detection limit of 5 percent and 0.01 percent, respectively.

The LIBS technology employs a laser and a spectrometer to measure, in situ and in real time, the constituents of the melt in a process furnace. A pulsed (5-10 ns duration) Nd:YAG laser at 532 nm is focused, through a fiber-optic cable, into a molten aluminum sample, generating high-temperature plasma consisting of excited neutral atoms, ions, and electrons. Any chemical compounds that are present in the sample are rapidly dissociated into their constituent elements. The laser-generated plasma is allowed to equilibrate several microseconds after the laser pulse, and optical emission from neutral and ionized atoms is collected and then dispersed by a spectrograph fitted with an intensified charge-coupled array detector. The line radiation signal amplitude can be calibrated quantitatively, thus providing the concentration of each element present.

One of the major challenges concerns the immersible probe design, which must be materially compatible with the melt at about 3,000°F and transmit adequate laser energy for LIBS measurement.

Progress and Milestones

- This project was selected through the Sensors and Controls Program FY99 solicitation and was awarded in January 1999. All tasks are scheduled for completion in 12 months.
- By June 1999, complete probe design and construction.
- By December 1999, complete testing of an installed probe on a laboratory furnace to compare the measured elemental constituents of several scrap aluminum specimens with their known concentrations to determine if the limit of detection (0.01 percent) and accuracy (5 percent) are achieved.
- Upon successful completion of this project, future activities may involve continuing field-testing, leading to a full-scale demonstration on a commercially operating furnace.



PROJECT PARTNERS

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